

**EFFECT OF GRINDING PROCESS PARAMETERS ON GRINDING FORCE OF
ALUMINIUM ALLOYS (AA6061-T6)**

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A final year report submitted in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing

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*Dedicated to all my beloved family members especially to
my father, mother, and sister.*

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

We certify that the report written by Alexius Anak An'yan entitled "Effect of grinding process parameters on grinding force of aluminium alloys (AA6061-T6)". We have examined the final copy of this project and that in our opinion; it is fully adequate, in terms of scope and quality for the awarding the degree. We herewith recommend that it be accepted in fulfillment of the requirements for the Degree in the Mechanical Engineering with Manufacturing.

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ABSTRACT

Significant developments have recently been made in the grinding of metals. Many researches have been devoted to determining the effect of these grinding parameters towards grinding force. The aim of this project is to study the effect of grinding process parameters namely depth of cut, number of passes, and use of coolant on grinding force of aluminium alloy (AA6061-T6). A three component force transducer dynamometer (Kistler Model Type 5070) was used to measure grinding forces in this experiment. A full factorial experimental design was used as the approach for the design of experiment. Through the analysis of variance (ANOVA) conducted, it was found that the most significant parameter is the usage of coolant followed by depth of cut. Meanwhile, number of passes was found to be not significant. In conclusion, the grinding force values increased as the number of passes became higher in proportional to depth of cut. The grinding force also increased if running in dry condition.

ABSTRAK

Pemipisan logam semenjak akhir ini makin telah memberi kesan ketara yang nyata. Banyak kajian telah telah diperuntukkan untuk mengenal pasti kesan proses pemipisan terhadap daya pemipisan. Projek ini bertujuan untuk mengkaji kesan proses pemipisan terhadap daya pemipisan pada aluminium aloi (AA6061-T6). Tiga komponen daya sensor jenis “ Kistler Model Type 5070” digunakan dalam kajian ini. Kaedah faktorial penuh digunakan dalam reka bentuk eksperimen ini. Matlamat analisa variasi dalam projek ini adalah untuk mengkaji jenis parameter yang mempunyai kesan besar terhadap daya pemipisan aluminium aloi (AA6061-T6). Melalui analisa variasi (ANOVA) yang dijalankan, ditemui bahawa parameter yang paling mempengaruhi adalah penggunaan pelincir dan kedalaman pemotongan. Manakala, bilangan laluan pemipisan didapati tidak mempunyai pengaruh yang besar. Kesimpulannya, nilai daya pemipisan akan meningkat sekiranya bilangan laluan pemipisan bertambah berkadar dengan kedalaman pemotongan. Daya pemipisan turut bertambah jika proses keadaan tanpa pelincir dijalankan.

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LIST OF SYMBOLS AND ABBREVIATIONS

D	-	diameter
mm	-	millimeter
rpm	-	rotation per minute
%	-	percentage
min	-	minute
GPa	-	GigaPascal
MPa	-	MegaPascal
AA	-	Aluminium Alloys
UNS	-	Unified Numbering System
°C	-	Degree Celcius
Hz	-	Hertz
kg	-	kilogram
kW	-	kilowatt
μm	-	micron meter
kg	-	kilogram

F_n	-	normal force
F_t	-	tangential force
F_r	-	resultant force
m/min	-	meter per minute
mm/min	-	milimeter per minute
N	-	normal force
s	-	second
V	-	volts
d_{wh}	-	diameter of wheel
L_c	-	length of contact
v_{wh}	-	periphral velocity
v	-	velocity
d_c	-	depth of cut
v_s	-	wheel speed

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CHAPTER 1

INTRODUCTION

1.1 Background

There are many considerations in the determination of the effect of grinding process parameters on grinding force of aluminium alloys. These considerations must be studied thorough so that accurate and precise results obtained. There has been high demand for better adequacy of industrial grinding process in order to meet the present requirements of standardization and safety. In this scenario, the comparison criteria presented in this project that are the grinding forces calculated due to the effect of the grinding process parameters.

It is well known that grinding force is one of the most important parameters in evaluating the whole process of grinding. The grinding force is resolved into three component forces, namely, normal grinding force F_n , tangential grinding force F_t and a component force acting along the direction of longitudinal feed which is usually neglected because of its irrelevance. The normal grinding force F_n has an influence upon the surface deformation and roughness of the workpiece, while the tangential grinding force F_t mainly affects the power consumption and service life of the grinding wheel. [2, 4] In order to study deep into the effect of grinding parameters on grinding force, the author set-up a measurement system to monitor the effects and try to find some difference in the changes of parameters on the grinding force performance based on the grinding parameters.

1.1 Problem statement

Recently, there is a need to produce good surface finish and tolerance tightening of workpiece. One of the machining processes best described is grinding process based on multi-pass cutting method of aluminium alloys. The wide variety application of aluminium alloy such as bearing in internal combustion engines and in industrial compressors have big significant to the industry development. [9] The grinding process as surface finishing process is required in all final stage of fabrication of material. [3] Steel-backed and solid aluminium bearings are used as connecting rod and main bearings in internal combustion engines and industrial compressors. The intention for this study is that multi-pass cutting is still a new research without an appreciation on the impact of poor experimental technique on the outcomes. Residual stresses in the workpiece as this might affect the grinding forces, cutting tool and surface finish that would trigger heat flux on interaction surface that related to the annealing of aluminium alloys. This influences the mechanical properties of aluminium alloys [14,4]. This project presents an applied approach to the problem, drawing on some practical examples and providing a description of the experimental techniques that were used.

1.2 Objectives

To investigate the effect of grinding process parameters on grinding force of aluminium alloys (AA6061-T6).

1.4 Scope

1.4.1 To study about the machine and material

To go through this objective, the resource of knowledge about the machine will be obtained from books, journals and internet. This studies scope to know the advantages and disadvantages of the grinding process parameters of machine on grinding force and also how to learn how to setup and running the grinding machine. This study will be focus in UNS AA 6061-T6 as workpiece.

1.4.2 To design the experiment

For experiment design, grinding parameters such as depth of cut (μm), multi-pass grinding (n), and type of lubricant coolant will be chosen as the variables for the experiment layout. The experiment layout has three levels of number of multi-passes cutting and three different level depth of cut as well as the type of lubricant coolant. The feed rate and cutting speed will be constant for the whole experiments. A range of eighteen experiments will be expected to running on the aluminium alloy (AA6061-T6) workpiece.

1.4.3 Analysis of Data

Analyzing data is based on grinding force created due to the parameters. The grinding force is detected and measured by the sensor of the grinding machine. Thus, the results can be analyzed.

1.4.4 Interpreting Data

The data will be plotted in graph based on the grinding process parameter and grinding forces. The plotted graph will be analyzed to obtain the results. The results will be interpreted to state the conclusion and to summarize the objective of the project. Finally, any result of the experiment cannot be standardized for any manufacturing field and any for experimental used.

1.5 Arrangement of report

From chapter 1, the project is elaborated on the background and the problem statement concerning the grinding effects parameters also state. The objectives are the priority concern in this study. For chapter 2, the literature review discussed about the recent studies that approximately close to the titles that author studied. The elaboration more deeply concerned in this chapter based on previous studies. In chapter 3, methodology mainly discussed about the method of experiment, machine, parameters selection and properties & material of the workpiece.

1.5.1 Flowchart

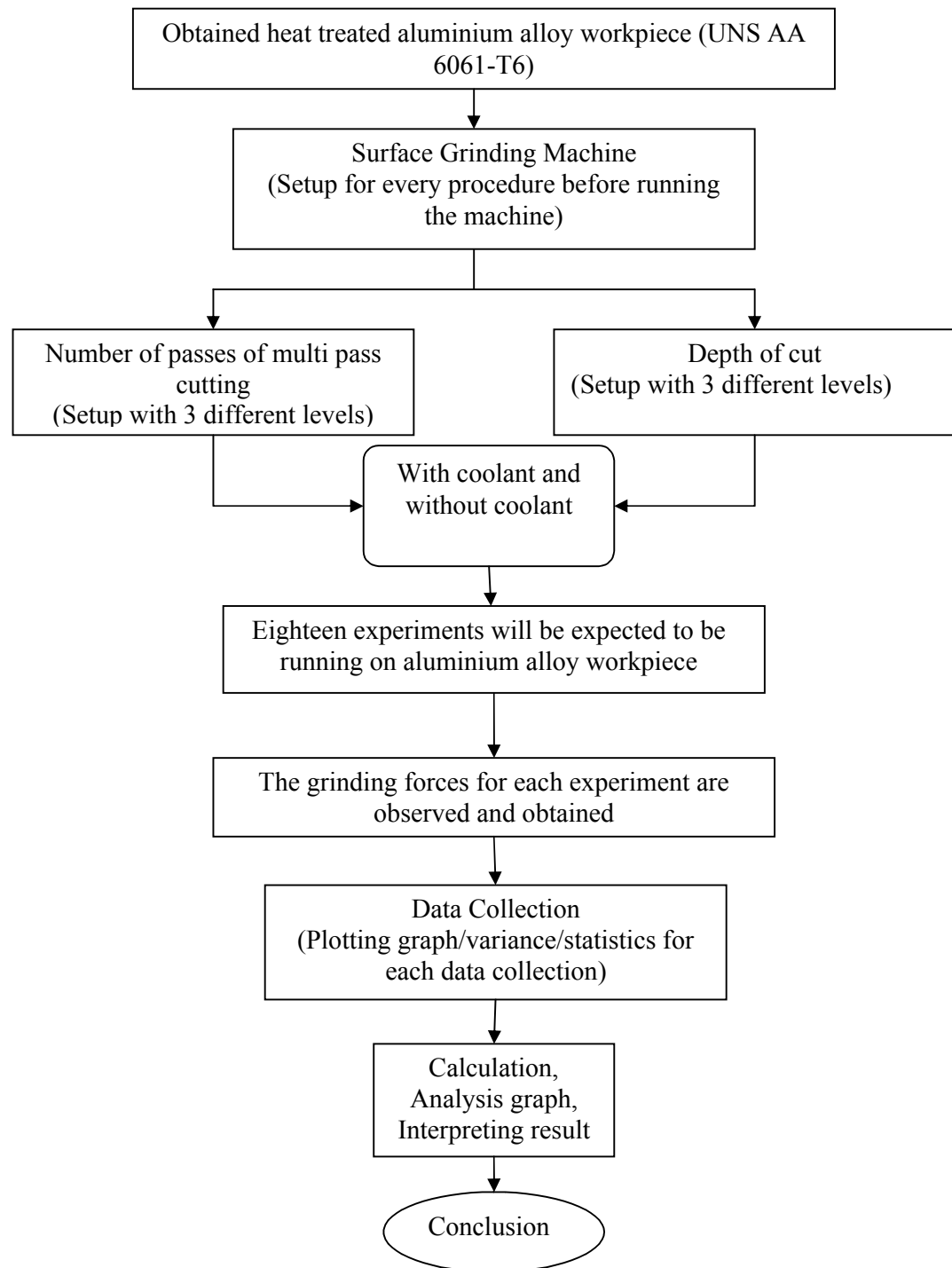


Figure 1.1 Research design flowchart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this project, author has chosen aluminium alloys from 6xxx series (UNS AA 6061-T6). Aluminium alloys are also among the most machinable of the common metal.[13,1] Cutting forces are generally low, and because aluminium is a good heat conductor and most alloys melt at temperatures between 500 and 600°C, cutting temperatures and tool wear rates are also low. When cut under proper conditions with sharp tools, aluminium alloys acquire fine finishes through turning, milling and milling, minimizing the necessity for grinding and polishing operations.[1] Their properties can be improved by furnace solution heat-treated quenched and furnace aged. In heat-treatment, it is cooled from an elevated temperature shaping process and artificially aged. This is given to products that not cold-worked after solution heat-treatment and for which mechanical properties or dimensional stability, or both, have been substantially improved by artificial aging (i.e., precipitation hardening at temperature higher than room temperature).[15]

Conventional machining processes make use of the ability of the cutting tool to stress the material beyond the yield point. Machining process also related with grinding forces. This because the grinding forces of the workpiece always depend on the cutting parameter of the machining process. Machining process relates to this finishing process. Thus, the grinding force always depends on the grinding parameters of the machining process. One of the machining processes used is the surface grinding; from that it is known that because of interrelation between the multi-pass grinding process and the grinding force of aluminium alloy.[4] In this chapter, it will be more understanding deeply how the cutting parameter can give effect to the grinding force of the aluminium alloy (AA6061-T6).

2.1.1 Aluminium Alloys

The important factors in selecting aluminium (Al) and its alloys are their high strength-to-weight ratio, their resistance to corrosion by many chemicals, their high thermal and electrical conductivity, their nontoxicity, reflectivity, and appearance, and their ease of formability and of machinability; they are also nonmagnetic.[5]

The principal uses of aluminium and its alloys, in decreasing order of consumption, are in container and packaging (aluminium cans and foil), In building and other types of construction, in transportation (aircraft and aerospace application, buses, automobiles, rail-road cars, and marine craft), in electrical applications (economical and nonmagnetic electrical conductor), in consumer durables (appliances, cooking utensils, and furniture), and in portable tools. Nearly all high-voltage transmission wiring is made of aluminium.[5]

2.2 Machining of Aluminium alloys (AA6061-T6)

Aluminium alloys is commonly machined with HSS, carbide, and PCD tooling. Silicon nitride-based ceramic tools are generally not used with aluminium because of the high solubility of silicon in aluminium.[1] The major machinability concerns with aluminium alloys tool life, chip characteristics and disposal, and surface finish. Tool life is a concern especially with alloys containing hard inclusions such as aluminium oxide, silicon carbide, or free silicon.[2] Two major classes of common machined aluminium alloys are cast alloys, used in automotive power train and component manufacture, and wrought or cold worked alloys, used specially in structural application.[6]

2.2.1 Milling process

Milling is a process in which a rotating cutter removes material while travelling along various axes with respect to the workpiece. Milling divided into two types of milling; conventional milling and climb milling. In conventional milling, the maximum chip thickness is at the end of the cut as the tooth leaves the workpiece surface. The advantages to conventional milling are that; (a) tooth engagement is not a function of workpiece surface characteristics

(b) contamination on the surface does not affect tool life. Disadvantage is there is tendency to be pulled upward (because of the cutter rotation direction).[4]

In climb milling, cutting starts at the surface of the workpiece where the chip is thickest. The advantage is that the downward component of the cutting force holds the workpiece in place. Climb milling is not suitable for the machining of workpieces having surface scale, such as hot worked metals, forgings, and castings. The scale is hard and abrasive and causes excessive wear and damage to the cutter teeth, thus shortening tool life.[4] Milling process considered as approximately good process but not that suitable enough for machining of aluminium alloys (6061-T6).

2.2.2 Turning process

Turning is a process where the part is rotated while it is being machined which typically carried out on lathe or similar machine tools. Turning process use single-point cutting tools which have various angles. The cutting force acts downward on the tool tip and, thus, tends to deflect the tool downward and the workpiece upward. The cutting force supplies the energy required for the cutting operation. The product of the cutting force and its radius from the workpiece center determines the torque on the spindle. The product of the torque and spindle speed determines the power required in the turning operation.[4] This relates that grinding force influenced by product of torque and spindle speed.

2.2.3 Grinding process

Grinding is a process carried out with a grinding wheel made up of abrasive grains for removing very fine quantities of material from the workpiece surface. Low material removal rate best described for grinding features. Compared to milling process with an infinite number of cutting edges, grinding required abrasive grains are thoroughly mixed with the bonding material and then pressed into a disc shape of given diameter and thickness.[16]

The purpose of grinding is to lessen the depth of deformed metal to the point where the last leftovers of damage can be removed by sequence of polishing steps. The scratch depth and the depth of cold worked metal underneath the scratches decrease with decreasing particle size of abrasive previous step.[2] Ernst and Daude (1990) have explained the decrease in grinding force as the wheel speed increases as being more due to the favourable kinematic conditions. Gühring (1990) confirms this beneficial effect of more favourable kinematic conditions, and also demonstrates that reduced mechanical strength at elevated temperatures has a critical influence on the reduction in the grinding force. Prins has established with single-point tests that the tangential force drops with increasing wheel speed and a constant depth of cut. In this case the explanation does not lie in any reduction in the cross section of the chip, as the depth of cut in the groove remains constant. Higher wheel speeds also result in a less ductile behaviour of the material as it is deformed, and so reduce the force and energy input required for the grinding operation.[14] Thus, grinding is the selected and most suitable process for the grinding of aluminium alloys. According to König and Stefens (1990), as the cutting edges engage the workpiece, the initial mechanism is that of elastic deformation. As the edge penetrates further, elastic and plastic deformation occur, followed ultimately by the formation of the chip. Figure 2.1 shows the deformation which takes place during the various stages as the cutting-edge engages the workpiece during grinding.[14]

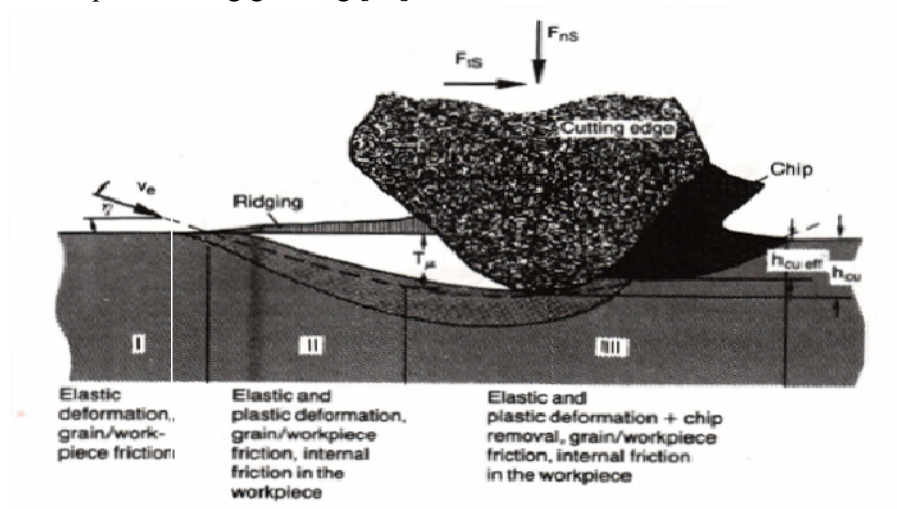


Fig. 2.1 Cutting edge engagement in grinding